

The Spacecraft Emergency Response System (SERS) For Autonomous Mission Operations

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Abstract

Today, most mission operations are geared toward lowering cost through unmanned operations. 7-day/24-hour operations are reduced to either 5-day/8-hour operations or become totally autonomous, especially for deep-space missions. Proper and effective notification during a spacecraft emergency could mean success or failure for an entire mission.

The Spacecraft Emergency Response System (SERS) is a tool designed for autonomous mission operations. The SERS automatically contacts on-call personnel as needed when crises occur, either on-board the spacecraft or

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within the automated ground systems. Plus, the SERS provides a group-ware solution to facilitate the work of the person(s) contacted.

The SERS is independent of the spacecraft's automated ground system. It receives and catalogues reports for various ground system components in near real-time. Then, based on easily configurable parameters, the SERS determines whom, if anyone, should be alerted. Alerts may be issued either via Sky-Tel 2-way pager, Telephony, or e-mail. The alerted personnel can then review and respond to the spacecraft anomalies through the Netscape Internet Web Browser, or directly review and respond from the Sky-Tel 2-way pager.

To date, nine missions have chosen the SERS for its adaptability to various ground systems and its low-cost commercial off-the-shelf availability. Research efforts continue to add collaboration tools such as whiteboarding, video conferencing, and palm-top devices to the SERS system. For details, please visit our NASA Web site at:

http://groucho.gsfc.nasa.gov/Code_520/Code_522/Projects/VMOC/vmocers.html"

Keywords

Emergency notification, autonomous operation, lights-out, Web-based, groupware, 2-way paging, Lotus Notes, Domino server

1. Introduction

While most missions are gearing toward autonomous operations, there are several issues must be addressed regarding spacecraft health and safety. During dim-lights or lights-out operations, how can operators and proper personnel be notified when there is an emergency? When autonomous operations are achieved, many missions will be tended to by only a handful of operators.

These personnel are not involved in day-to-day operations for a specific mission as before. When an emergency occurs, they need to be presented with enough information under a unified format so problems can be diagnosed quickly and correctly. It is also very important that these personnel be notified in a timely manner and the information be presented remotely via reliable communication devices.

The Spacecraft Emergency Response System (SERS) has been designed to satisfy all the requirements mentioned above. It is extremely user-friendly. Anyone who is familiar with an Internet browser can learn to use the SERS in an instant. Because it is Web-based, easy access and remote response is made possible. Information that includes current alerts and past operating history is presented on-line for immediate reference. Advanced communication devices are built around SERS for effective alert notification. The SERS has been implemented as the first safeguard for future autonomous operations.

The SERS runs on standard Windows-NT systems. It is designed to be fault-tolerant via a dual processor configuration. In normal mode, the SERS contacts the Sky-Tel paging service via the Internet. Analogue lines are used as backups.

The SERS also contains a Process Monitor and a System Monitor. The Process Monitor routinely checks the ground system to see if all necessary processes are performing each task properly. The System Monitor checks all mission-critical computers to see if they are operational. When any process is missing or any system is down, proper personnel will be notified.

The SERS is based on IBM's Domino 4GL (formerly Lotus Notes), a commercial tool widely used for business applications. Domino is a web-enabled document database, which is ideally suited to the information tracking typically done in spacecraft operation centers. Because the SERS is based on Domino technology, it is

easily extensible to other applications in a mission. For example, a SERS add-on feature has been built to allow logging of spacecraft anomalies during Integration and Testing. All corrective or remedial actions can then be logged by engineers and managers for future reference. Pass Summaries can also be automatically generated to relieve tedious work from mission operators. Domino also provides workflow capabilities to guide reports through review/signature cycles, etc.

2. System Architecture

A NASA SERS system consists of 1-3 Pentium PCs running Windows NT and the following hardware and software:

Table 1. SERS Hardware and Software List

Hardware	
COTS	Analogue Modem
	Dialogic Telephony Board
Software	
COTS	IBM Lotus Domino
	Peloria Grand Central Pager Gateway
	Phonesoft Telephony
Custom	Regular Episode Processor
	Process Monitor
	System Monitor

The SERS was designed with a concept that using commercial off-the-shelf (COTS) products could save both time and money during development. Although there were many debates over the true experiences of this concept, the SERS certainly benefited from it. Up to today nine missions have chosen to use the SERS because of its low-cost and robust structure. Figure 1 shows the unique capabilities that the SERS possesses:

- 2-way communications to allow acknowledgement and failover
- Emergency information synthesis and presentation
- Smart notification system
- Web-based report generation
- On-line staff scheduling and resource management
- Access to on-line documentation, telemetry, and mnemonics
- Episode-Incident-Alert Model for detecting and responding to events
- Configurable definitions of emergencies and schedule personnel
- Collaborative tools for remote work
- Capability for automated and manual sensors logging
- Combination of commercial and custom hardware and software

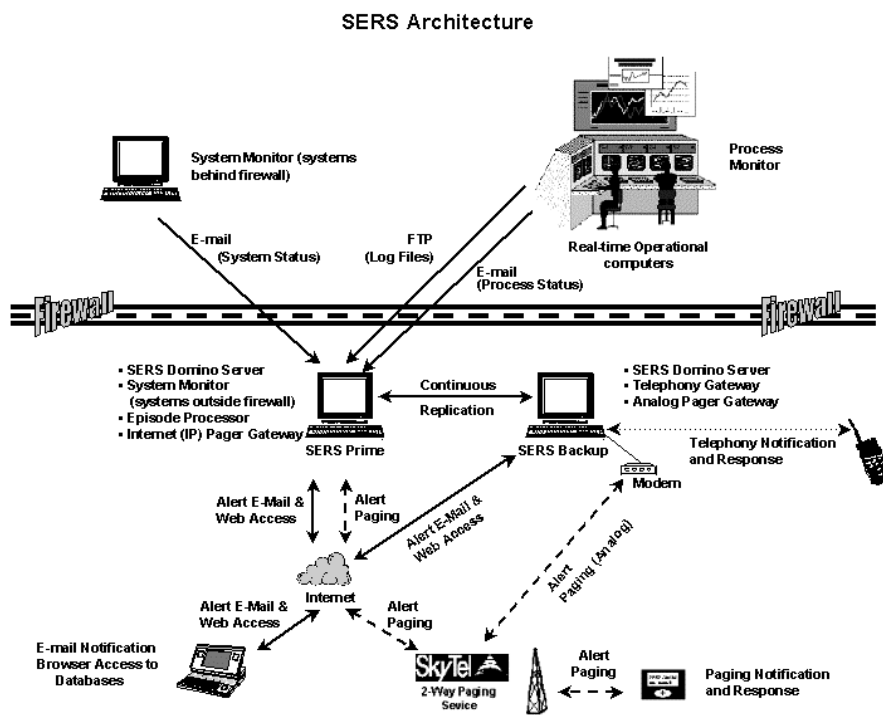


Figure 1. SERS Architecture

The SERS design allows the Internet convenience mentioned above, yet it honours the tight security for the ground systems and the spacecraft. The information is passed through the firewall uni-directionally with port-to-port defined file transfers and station-to-station defined email. A backup SERS server is always on a hot-standby mode, ready to take over the operations in case the primary server is hanging or down completely. Pager notifications can be done through the Internet or a regular analogue line with a modem. Telephony is used when the user chooses so, or when the user is unreachable through paging. For non-emergencies, or for information only, the users can also be reached via email.

3. SERS functionality

The SERS server is powered by the IBM Domino technology using Lotus Notes as its database. After sending alert notifications, SERS monitors for team members' responses. If alert notifications are sent via SkyTel's 2-Way paging network, the team member will receive an alphanumeric page that contains background information on the alert as well as three options to reply back to SERS: (1) ask for more information; (2) defer responsibility to a backup; or (3) accept responsibility. Similarly, SERS can call a team member on the telephone, read the alert notification (via a text speech engine) and allow the operator to reply to the alert notification via keys on the telephone. E-mail alerts contain the same alert information with the addition of a URL that links the person to the appropriate SERS report. (Figures 2 and 3) Based upon the responses to the alert notifications, SERS will identify and alert backup team members as necessary.

All this functionality is unified under a common Web-based user-friendly graphical interface. Users have point-and-click access to their operational information (e.g. event logs and mnemonics), historical information (e.g., I&T databases) and utilities (e.g. configuration files

and tools). Extensive effort has been dedicated to developing a suite of tools that are not only functional, but also highly useful. Usability tests have been and are continuously conducted to ensure that product integrity is maintained during development and upgrade.

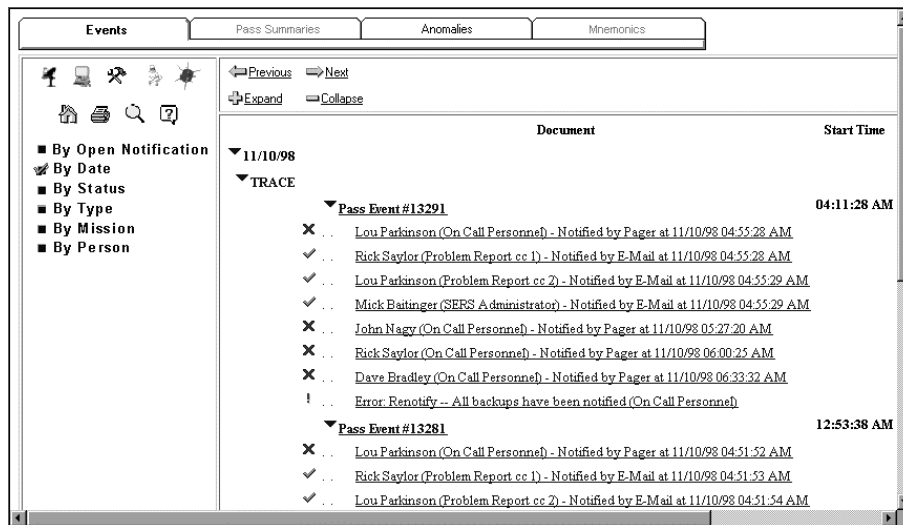


Figure 2. The Main Page of the SERS Event Database



Figure 3. An Individual Event Report

4. SERS Security

The SERS security is provided by the Domino server. It supports encryption with Secured Socket Layer (SSL), digital signatures, and password protection. The SERS administrator maintains an Access Control List (ACL) to determine what privileges the user has in the database. It controls who can access a database, view forms within a database, and view/edit individual fields within a form. This versatile capability not only protects data from unauthorized access, but also increases the overall usability of the software by dynamically determining and presenting only the information relevant to the user.

5. SERS Users

The SERS anomaly tracking system was deployed for the TRACE mission in the fall of 1997. The system was extensively used by the operators and engineers. The fully operational SERS was released in April, 1998 when the TRACE satellite was launched. The users have been pleased with the friendly interfaces and the useful information the SERS provides.

Many improvements and upgrades have been made since the first release. The SERS has been reprogrammed to accommodate a multi-mission environment that consolidates resources and reduces cost. More missions such as MAP, IMAGE, SWAS, FAST, WIRE, SAMPEX, HESSI, and SAIL are in the process of integrating SERS into their systems.

6. Future Development

Future development of the SERS includes technologies in the areas of advanced paging systems, PDA's, information synthesis and visualization, intelligent autonomous systems, remote access and security, groupware and collaborative tools.